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Exploring music-evoked autobiographical memories in healthy aging

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Master's Thesis
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Tiivistelmä - Referat – Abstract

Objectives. This study sought to investigate factors related to the elicitation of music-evoked autobiographical memories (MEAMs) in healthy aging to improve overall understanding of the phenomenon and to enhance the selection of optimal musical stimuli to be used for the neurological rehabilitation and care of elderly individuals. The characteristic contents of MEAMs of healthy older individuals were also explored.

Methods. 113 healthy senior subjects (aged 60 – 86 years) listened to 70 preselected song excerpts and rated each on a 5-point Likert scale in five domains: valence, emotional intensity, arousal, familiarity and autobiographical salience. Correlational and linear mixed model analyses were conducted to discover the relationship between the rated variables. Eighty-one participants additionally chose to verbally describe their MEAMs in further detail. These submitted inserts (n = 2790) were manually categorized and labelled into non-mutually exclusive groups and sub-groups.

Results and conclusions. The analyses revealed that all rating variables had statistically significant positive relationships with one another. Valence, emotional intensity, arousal and familiarity all had significant positive effects on the dependent variable autobiographical salience. Thus, in order to maximally evoke MEAMs in healthy elderly individuals, the chosen musical stimuli should be regarded by the listener as being pleasant, emotionally intense, physiologically arousing and familiar. The contents of elderly individuals' MEAMs often involved music-related activity, such as singing, dancing or listening to music. They also frequently contained details of specific people or locations. Lastly, they often weren't very temporally specific and memories from adolescence were more common than other life periods.

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Music-evoked autobiographical memories, MEAMs, aging, rehabilitation, elderly care

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Tiivistelmä - Referat – Abstract

Tavoitteet. Tämä tutkielma tarkasteli musiikin herättämiä omaelämänkerrallisia muistoja (lyh. musiikkimuistot) ja niiden viriämiseen liittyviä muuttujia terveillä ikääntyneillä. Tavoitteena oli yleisesti tuottaa uutta tietoa musiikkimuistoihin liittyvistä tekijöistä sekä parantaa muistoja herättävien musiikkiärsykkeiden valintaa ikääntymiseen liittyvien neurologisten sairauksien kuntoutuksessa ja hoidossa. Lisäksi selvitettiin, millaiset ominaisuudet ja muistisisällöt ovat tyypillisiä terveiden ikääntyneiden musiikkimuistoissa.

Menetelmät. 113 tervettä senioria (60–86 vuotta) kuunteli 70 katkelmaa ennalta valituista musiikkikappaleista ja arvioi jokaisen 5-portaisella Likert-asteikolla kappaleiden miellyttävyyden, tuttuuden sekä kuuntelun aikana virinneiden tunnekokemusten voimakkuuksien, vireystilamuutoksien ja omaelämänkerrallisten muistojen määrän suhteen. Korrelaatioanalyysia ja lineaarisia sekamalleja käytettiin koehenkilöiden arvioista muodostettujen muuttujien välisten yhteyksien selvittämiseen. Lisäksi 81 koehenkilöä kuvaili tarkemmin virinneitä muistojaan vapaaehtoisesti tehtävän aikana. Annetut muistokuvaukset (n = 2790) kategorisoitiin manuaalisesti ryhmiin ja alaryhmiin, jotka eivät olleet toisiaan poissulkevia.

Tulokset ja johtopäätökset. Miellyttävyys, tuttuus, tunnevoimakkuus, vireystilamuutos sekä omaelämänkerralliset muistot olivat positiivisessa yhteydessä keskenään. Miellyttävyys, tuttuus, tunnevoimakkuus ja vireystilamuutos olivat kaikki tilastollisesti merkitseviä ennustajia omaelämänkerrallisten muistojen määrälle. Terveiden ikääntyneiden musiikkimuistojen herättämiseen tulisi siten valita musiikkia, mikä on kuuntelijalle miellyttävää, tuttua, tunteita herättävää, sekä vireystilaa nostattavaa. Ikääntyvien musiikkimuistoihin sisältyi usein musiikkiin liittyvää toimintaa, kuten laulamista, tanssimista tai musiikin kuuntelua. Ne sisälsivät usein myös tietoja tietyistä ihmisistä tai paikoista. Muistot eivät tyypillisesti olleet ajallisesti kovin tarkkoja. Ne ajoittuivat useammin nuoruuteen kuin muihin ikäkausiin.

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TABLE OF CONTENTS

Foreword

The data in this study was collected during the first phase of data collection in a 3-year longitudinal cohort study conducted by the Cognitive Brain Research Unit (CBRU) at the University of Helsinki. The cohort study, *Neuroprotective effects of senior choir singing in healthy ageing,* aims to determine the long-term efficacy of senior choir singing on cognitive, emotional and social functioning in normal ageing. Within the baseline stage of the senior choir study, part of the subjects (n = 113) participated in a music listening and rating task and the data derived from this task was used for the first quantitative part of this Master's thesis (*MEAMs and Associated Factors)*. Participants were also given the voluntary opportunity to verbally describe autobiographical memories evoked by the songs in further detail. These verbal inserts were used to explore the characteristic contents of music evoked autobiographical memories in the second qualitative part of this thesis (*Content Analysis of MEAMs)*.

I was fortunate enough to be able to participate in some of the data collection and conducting of experiments within this research project as a research assistant for CBRU. I would like to personally thank my supervisors, Anni Pitkäniemi and Teppo Särkämö (Project manager), for their guidance and support throughout the process of planning, formulating and writing my thesis.

1 Introduction

Music is a powerful stimulus. Hearing a specific musical piece can instantly transport an idle mind back to a particular episode from the past, whilst simultaneously awakening retained intricate details associated with that particular musical memory. These types of memories are known as music-evoked autobiographical memories (MEAMs), which are defined as recalled autobiographical memories of past events that are triggered spontaneously and often involuntarily by musical stimuli (Cuddy, Sikka, Silveira, Bai & Vanstone, 2017; Rasmussen & Bernsten, 2009). This autobiographical memory evoking process is thought to occur due to the complex way in which music simultaneously activates multiple interacting brain networks associated with memory, emotion, perception, sensory and motor functions (Janata, 2009). Overall, music has been found to be a highly effective cue for drawing out autobiographical experiences from memory (Cady, Harris & Knappenberger, 2008; Scherer & Zentner, 2001). Musical cues lead to enhanced retrieval of autobiographical memories when compared to traditional word cues (Schulkind & Woldorf, 2005), and when compared to photographic stimuli, music appears to evoke more vivid memories (Belfi, Karlan & Tranel, 2016).

Music that has been listened to during key episodes of an individual's life hold strong connections to that person's sense of self and autobiographical memory (Batcho, 2007). A sense of self is composed of memories of events and experiences from life, which contribute in forming a cohesive personal identity (Conway, 2005). Autobiographical memory is a distinct type of self-referential memory, which expands a network of personal experiences and episodes collected from the subjective history of each individual's life (Vanderveren, Bijttebier, & Hermans, 2017). Autobiographical memories can contain various types of detail from episodic memory, such as specific life experiences, people, events, locations or objects, as well as details from semantic memory, such as general knowledge about the world or information about oneself (Williams, Conway & Cohen, 2008).

Autobiographical memory is essential for several different cognitive functions supporting overall well-being and the effective functioning of the self (Vanderveren et al., 2017). For example, autobiographical memory can help in directing current behaviour or predicting future behaviour by providing essential information about past events to compare to (Baddeley, 1987). Autobiographical knowledge is also essential for building a consistent life timeline and sense of self in order to realise who you are now, were before and could be in the future (Conway, 2005). Autobiographical memories additionally serve to create and strengthen social bonds between people by facilitating social interaction, fuelling conversations, and enabling the sharing of experiences as well as increasing intimacy and sympathy (Williams, 2008).

The emergent need to acquire more cost effective, non-invasive and non-pharmacological treatments for the rehabilitation and care of elderly individuals globally has highlighted the importance of investigating the nature of MEAMs further and to find ways in which autobiographical memory evoking music could be used within future healthcare to improve the daily lives of seniors. As people get older and transition into retirement, they increasingly report using music specifically for emotional self-regulation purposes (Saarikallio, 2011). Another seminal reason reported to motivate elderly individuals' day-to-day music listening is music's ability to evoke autobiographic memories (Laukka, 2007). Elderly individuals also consider music to be a meaningful component of daily life, using it for purposes of relaxation, revival, entertainment - and even to alleviate feelings of loneliness (Saarikallio, 2011). MEAMs have been found to be largely spared from deterioration in normal aging (Collett, Lee, Shabahang, Vanstone & Cuddy, 2012) and have also been observed in patients with severe acquired brain injury (Baird & Samson, 2014) as well as Alzheimer's disease (AD) (Cuddy, Sikka & Vanstone, 2015; El Haj, Postal & Allain, 2012). Singing and listening to familiar songs has even been found to improve autobiographical memory in persons with dementia (PWDs) (Särkämö et al., 2014). The fact that MEAMs appear to remain intact in diverse ageing populations demonstrates an important motive for implementing the use of music evoked memories within elderly rehabilitation and care to support wellbeing until the very late stages of life.

The contribution of emotional, attentional and memory-related factors in MEAMs as well as their characteristic contents have not yet been extensively explored in healthy elderly individuals. Determining the relationships between MEAMs and possible associated factors can provide novel insight into this little understood area of memory research and provide guidance in finding the optimal types of musical stimuli to be used for maximal memory evocation in older adults. Previous research indicates that there is a close relation between the power of a song to evoke MEAMs and subjectively rated familiarity, pleasantness and emotionality (Cuddy et al., 2015). Moreover, autobiographical memory research has repeatedly verified the existence of a positive relationship between emotional valence, emotional intensity, and autobiographical salience (Janata, Tomic & Rakowski, 2007). The first part of this study, *MEAMs and Associated Factors,* will explore the following emotion- and attention-related factors: valence (how much a song is liked or disliked), emotional intensity (the strength of emotion attached to a song), arousal (how a song impacts current states of arousal), familiarity (how familiar a song feels to an individual), and their association to the autobiographical salience (how much the song evokes autobiographical memories).

1.1 MEAMS and Associated Factors

The following section will explore the above-listed factors - valence, emotional intensity, arousal and familiarity - in relation to the amount of autobiographical memories evoked by music in further detail, discuss previous findings and make initial predictions about expected results. The four factors were measured by questions 1-4 (see Table 1) in the music listening and rating task of this study.

1.1.1 Valence "*How pleasant did you find the song?"*

The valence of an emotional experience is usually defined in accordance with the Circumplex Model of Affect, which proposes that all affective states can be understood by their relative locations on two separate neurophysiological dimensions, arousal and valence (Russel, 1980). The model describes emotional valence as the extent to which an emotion is positive or negative, forming a continuum from positive (pleasantness) to negative (unpleasantness). Arousal, on the other hand, is described as the intensity of an emotional experience, forming a continuum from low (passive) to high (active) (Russell, 1980). In this thesis, the valence rating assigned to an individual's experience of listening to specific music excerpts describes how pleasant (high valence) or unpleasant (low valence) they find the piece.

The subjectively rated valence or pleasantness of music has not been widely explored in relation to how it affects the incidence of MEAMs. However, the few studies that have explored this relationship have yielded conflicting results. One study found that high valence (positive emotion) in music is an important modulator of episodic long-term memories (Eschrich, Münte & Altenmüller, 2008). Another study found that participants had a higher number of personal memories when listening to music rated as being high in valence (Krumhansl & Zupnick, 2013). However, not all studies have found this same effect. For example, a study by Platz et al. (2015) found that musical pieces with high valence ratings did not contribute to a higher number of MEAMs. Due to the conflicting results from preceding literature, valence ratings are not expected to have a distinct relationship with the amount of MEAMs elicited in this thesis.

1.1.2 Emotional Intensity "*How strong emotions did the song evoke?"*

The emotional intensity of a musical excerpt depicts the overall impact of music on an individual's emotional state, be it in a negative or positive direction (Schäfer, Zimmermann, & Sedlmeier, 2014). Emotions are a fundamental feature in the experience of music (Juslin & Laukka, 2004). Conversely, music has the ability to modulate brain activity in structures which are important for the experiencing

of emotions (Koelsch, 2014). Emotions are also known to have a key role in the retrieval and encoding of personally salient events (Holland & Kensinger, 2010).

The relationship between MEAMs and emotional intensity has been studied previously by Janata et al. (2007) who found that a high frequency of MEAMs was associated with experiencing strong emotions. Similarly, a study by Schulkind et al. (1999) found that the emotional intensity experienced in response to music had a strong correlation with the amount of MEAMs elicited. They further discovered that musical excerpts which elicited intense autobiographical memories also triggered intense emotions (Schulkind et al., 1999). In this thesis, these findings are expected to be replicated, so that the emotional intensity of a musical experience has a positive relationship with the amount of MEAMs elicited.

1.1.3 Arousal "*How did the song affect your state of arousal?"*

Listening to music can alter listeners' levels of physiological arousal in diverse ways. The exact change in the direction of an arousal state is affected by a multitude of factors, ranging from specific qualities of a musical stimulus to various situational and individual-level factors (Dillman Carpentier & Potter, 2007). For example, music that is considered relaxing can decrease arousal state and help listeners calm down by reducing stress (Knight & Rickard, 2001; Pelletier, 2004). Other types of music, such as those with faster tempos, can make people more energized and consequently result in higher arousal (Husain, Thompson, & Schellenberg, 2002).

The relationship between music-induced arousal and simultaneously evoked autobiographical memories have not been studied comprehensively. Emotionally arousing non-musical stimuli, however, are known to be consistently better remembered than less arousing or neutral stimuli, indicating that increased levels of emotional arousal can enhance memory encoding and consolidation (Samson, Dellacherie & Platel, 2009). Moreover, one study found that higher emotional arousal ratings of musical pieces were associated with better recognition of the same musical pieces, concluding that episodic memory for music was enhanced by higher arousal level (Eschrich, Münte & Altenmüller, 2005). On the topic of highly arousing musical stimuli and autobiographical memories specifically, one study found that subjects had a higher number of personal memories when listening to high arousal music, or music that made subjects more energized (Krumhansl & Zupnick, 2013). In this thesis, arousal level is presumed to have a positive relationship with the amount of MEAMs elicited.

1.1.4 Familiarity *"How familiar was the song to you?"*

A familiar piece of music can be a powerful stimulus for cueing the recall of an autobiographical memory. Highly familiar music has previously been identified as being an effective autobiographical memory retrieval cue in young adult participants (Janata et al., 2007). Functional neuroimaging research also supports the notion of a strong connection between familiarity and autobiographical salience, with findings pointing to shared neural networks and brain regions between these two processes (Janata, 2009). However, it appears that the relationship between song familiarity and MEAMs is more complex than expected. Firstly, it is important to note that not all familiar music will evoke autobiographical memories (Janata et al., 2007). Secondly, Janata et al. (2007) found that a small portion of unfamiliar songs managed to also evoke memories in their participants. From this finding they contemplated that perhaps mere familiarity with a particular genre of music could be enough to ignite associative memory networks and thus succeed in triggering autobiographical assocations (Janata et al., 2007).

Interestingly, one study found that the effects of song familiarity varied depending on the age of the listener (Ford, Rubin & Giovanello, 2016). In younger people, familiarity was associated with improvements in memory details but in older adults, familiarity was associated with affective positivity in memories. Additionally, they found that in all age groups, highly familiar songs triggered memories which were more emotionally positive and temporally specific (Ford et al., 2016). In this thesis, familiarity is predicted to have a positive relationship with the amount of elicited MEAMs, so that songs rated as being more familiar will elicit more MEAMs.

1.2 Content Analysis of MEAMs

Exploring the qualitative content of elicited music memories can help to enhance universal understanding of the types of detail generally recollected by elderly individuals when listening to music. In the second part of this study, *Content Analysis of MEAMs*, memory contents were explored by examining voluntary verbal descriptions given within a song listening and rating task. Categories for the different types of memory submissions were mostly created manually by noting reoccurring themes that arose in the submitted pool of memory inserts. However, some categories were formed based on a theoretical standpoint, such as the widespread self-memory system model by Conway and Pleydell-Pearce (2000). The model proposes that autobiographical memories are constructed in the moment within a self-memory system composed of the working self and an autobiographical knowledge base. The working self acts as a control centre, manipulating the accessibility of the autobiographical knowledge base for memory recall and encoding processes (Conway, 2005). The

autobiographical knowledge base stores all information related to the self and categorizes it into three levels of representation by the amount of time that each level refers to (Conway & Pleydell-Pearce, 2000).

Starting from the finest level of detail and shortest timeframe are *event-specific* memories, which contain detailed knowledge from one exact timepoint in a person's life such as a particular childhood birthday party or high school graduation. The next level of representation belongs to *general events*, which signify recurring or similar events that cluster together through some particular theme, such as Sunday dinners with family or evenings spent at a particular café in adolescence. The third level is represented by *lifetime* periods, which are less temporally specific than the two previously described categories and are characterized by a particular themed time period in life such as teenage years as a whole or time spent at university (Conway & Pleydell-Pearce, 2000). These three levels of autobiographical knowledge will be used as distinct theoretical categories in the characterization of MEAM contents.

Continuing on the topic of memory time frames, further temporal categories will be added to represent different age categories at the time of memory consolidation. Previous literature advocates the existence of a reminiscence bump effect for songs heard in the early years of adolescence (15-24 years of age) so that compared with other life periods, songs heard in this period of youth tend to have a stronger relationship with autobiographical memories and generally evoke a larger amount of memories (Schulkind, Hennis & Rubin, 1999). However, a more recent study by Platz et al. (2015) failed to replicate this finding and only found the total number of MEAMs to be marginally influenced by a memory bump effect. To further investigate the existence of the reminiscence bump in this study, four sub-categories will be created within the lifetime period category to represent different lifetime periods divided by age; Childhood (0-14 years), Youth (15-24 years), Adulthood (25-59 years) and Old Age (60+ years).

Previously, the characterization of MEAM contents was undertaken in a study of healthy undergraduate students by Janata et al. (2007) who presented their subjects with 30 randomly selected music excerpts from billboard charts from participants' childhood and youth (7-19 years of age). Following each excerpt, participants answered a set of follow up questions about song familiarity, autobiographical salience, the content of MEAMs, and self-assessed levels of autobiographical knowledge (Conway & Pleydell-Pearce, 2000). The MEAM content analysis revealed that approximately 40% of MEAMs (songs which were rated as somewhat/strongly autobiographical)

evoked memories of people or a life period. Approximately 20% of MEAMs evoked memories of a specific event or place. Following a word frequency analysis of verbal memory contents, they found that the most common activities to come up in participants' descriptions of MEAMs were dancing, driving and singing. They concluded that these common ways of interacting or responding to music were a fundamental part of MEAM contents (Janata et al., 2007).

1.3 Rationale of the study

This study has two main purposes and is conceptually divided into two parts.

The first part aims to investigate factors related to the elicitation of MEAMs in healthy elderly populations to improve the selection of optimal musical stimuli to be used for the neurological rehabilitation and care of elderly individuals. The following research questions are addressed:

1a. What kind of relationships exist between individual rating variables (valence, emotional intensity, arousal, familiarity) and the amount of MEAMs elicited?

1b. Which combination of these four variables best explains the amount of autobiographical memories evoked by music?

Hypotheses within these research questions include:

1.1. Emotional intensity has a positive relationship with the amount of MEAMs elicited (higher levels of emotional intensity elicit more MEAMs).

1.2. Arousal has a positive relationship with the amount of MEAMs elicited (higher levels of arousal elicit more MEAMs).

1.3. Familiarity has a positive relationship with the amount of MEAMs elicited (songs which are more familiar elicit more MEAMs).

The second part of this study incorporates a more explorative approach and aims to advance general understanding of the qualitative contents of MEAMs in healthy aging populations by analyzing participants' verbal reports of MEAMs. The following research questions are addressed:

2. What kinds of information and levels of detail do MEAMs of healthy elderly individuals commonly contain?

Additionally, to investigate the possible existence of a reminiscence bump, one distinct hypothesis was formulated within this explorative part of the study:

2.1. The frequency of MEAMs reported in the period of youth (15-24 years of age) is higher than other lifetime period age groups.

2 Methods

2.1 Participants

A total of 113 subjects participated in this study, 76% of which were female (n = 86) and 24% male (n = 27). The mean age of participants was 70.76 years (SD = 5.38; range = 60 – 86). All participants were right-handed and native Finnish speakers. A large proportion of the participants were musically active, with 78 being active choir singers and 83 having at least one weekly musical activity after the age of 60. None of the participants had been diagnosed with neurological, psychiatric or substance abuse disorders at the time of the study. Participants were mostly recruited through the Helsinki Adult Education Centre (HAEC) and Vantaa Adult Education Centre (VAEC). The study was approved by the Ethical Review Board in the Humanities and Social and Behavioural Science of the University of Helsinki, and all participants gave written informed consent.

2.2 Data Collection

The data in this study were collected during the first phase of data collection in a 3-year longitudinal cohort study by the Cognitive Brain Research Unit (CBRU) at the University of Helsinki. The cohort study, *Neuroprotective effects of senior choir singing in healthy ageing,* aims to determine the long-term efficacy of senior choir singing on cognitive, emotional, and social functioning in normal ageing, as compared to a non-singer control group. Within the baseline stage of the senior choir study, part of the subjects (n =113) participated in a music listening and rating task. The data derived from this listening and rating task were used in this study.

2.3 Stimuli

In order to find the optimal amount of songs and to test the applicability of the listening and rating task, a pilot study was conducted prior to the main study. The pilot study involved 11 elderly participants and 225 songs. Based on findings of familiarity and autobiographical salience, a total of 140 songs were chosen and these were split into two sets of 70 songs (see Appendix B). Participants were carefully assigned to the two song list groups to ensure a balanced ratio between participant age, gender and proportional amount of choir singers to controls.

The songs selected represent some of the most played songs in Finnish radio from the 50s to 80s. They varied in musical genre (pop, rock, jazz and folk) and presumed familiarity. Both sets of 70 songs had 10 folk songs each and a total of 15 songs per decade from 1950s to 1980s. The selected pool of songs included 80 songs sung in Finnish, 58 songs sung in another language (primarily English) and two instrumental songs. Selection criteria excluded songs with extremely high or

extremely low ratings of autobiographical salience and familiarity. The song excerpts were approximately 30 second in length and mp3-format. They were chosen to best represent the most characteristic and recognizable part of the original song. A one-second half sine wave fade-in was applied to the beginning of every excerpt and a three-second fade-out was applied to the end of each excerpt.

2.4 Procedure

A web browser application was designed specifically for this project so that participants were able to complete the music listening and rating task at any time or location. The task was performed either on a personal computer or tablet computer. The task was conducted entirely in Finnish language. Before starting the actual task, participants did a short test trial to get accustomed to the user interface, practice submitting verbal input by microphone/text and to set their output and input volumes to suitable levels. The music listening and rating task comprised of subjects being presented with short excerpts of songs from various musical genres and decades. Each participant listened to 70 song excerpts in total and after each sample they were asked to rate the song on a 5-point Likert scale in five domains (valence, emotional intensity, arousal, familiarity and autobiographical memories). Table 1 lists the five questions probed, translated into English. The questions were presented sequentially after each song in the same order. The application allowed participants to move to the next song after all five questions had been answered. Participants were allowed to replay song excerpts within the task.

Table 1. *Questions and answers presented to participants in the music listening and rating task.*

DOMAIN	QUESTION	ANSWER	VALUE
Valence	*How pleasant did you find the song?*	Very pleasant	5
		Quite pleasant	4
		Neutral	3
		Quite unpleasant	2
		Very unpleasant	1
Emotional intensity	*How strong emotions did the song evoke?*	Very strong emotions	5
		Strong emotions	4
		Moderate emotions	3
		Weak emotions	2
		No emotions	1
Arousal	*How did the song affect your state of arousal?*	Increased arousal significantly	5
		Increased arousal moderately	4
		Neutral (arousal level unaffected)	3
		Decreased arousal moderately	2
		Decreased arousal significantly	1
Familiarity	*How familiar was the song to you?*	Very familiar	5
		Somewhat familiar	4
		Neutral (not unfamiliar or familiar)	3
		Somewhat unfamiliar	2
		Unfamiliar	1
Autobiographical salience	*How much personal memories did the song evoke?*	Significant amount of personal memories	5
		Many personal memories	4
		Some personal memories	3
		Few personal memories	2
		No personal memories	1

2.5 Content Analysis

In addition to rating songs via the probed questions (Table 1), participants were given the voluntary opportunity to verbally describe personal memories evoked by each song in further detail. The input of verbal descriptions was made possible either by writing into an allocated text space or making an audio recording within the application. The content analysis and categorization of submitted inserts was conducted manually by first categorizing participants memory inserts into sub-groups and later these sub-groups were clustered together within overarching groups described in Table 2. Individual inserts were not exclusively assigned to one specific group or sub-group but could be categorized into multiple different groups simultaneously. The inserts were also divided into two categories separating those which did not contain a description of a MEAM (Non-MEAM inserts) and those which did (MEAM inserts).

Table 2. *Names and definitions of insert groups and sub-groups.*

GROUP	SUB-GROUP	INSERT CONTENT
Action memory	Dancing	A memory of dancing
	Singing	A memory of singing
	Performing	A memory of performing
	Listening	A memory of listening to the song
	Playing(instrument)	A memory of playing the song on an instrument
Specific detail	Location specific	A specific location
	Object specific	A specific object
	Person specific	A specific person/people
	Event specific	A specific event
	General event	A reoccurring event
Lifetime period		A distinguishable and themed time of life, such as:
	Childhood	Period of childhood (age 0 – 14)
	Youth	Period of youth (age 15 – 24)
	Adulthood	Period of adulthood (age 25 – 59)
	Old age	Period of old age (age 60 +)
Semantic content	Artist related content	Information or mention of artist / song composer
	General information	General knowledge, facts or claims
Associative detail	Association	A general association/mental connection
	Feeling	A memory of a feeling/emotional experience
	TV/Cinema/Radio	A memory of watching TV, going to the cinema or listening to radio
Other categorizations	MEAM insert	MEAM related content
	Non-MEAM insert	Not MEAM related content
	Opinion	A personal opinion
	Multiple memories	Description or mention of more than one memory

2.6 Statistical Analyses

The research design in the first part of this study, *MEAMs and Associated Factors*, was explorative by nature, intending to identify which factors were related to the amount of autobiographical memories evoked. Considering that each rating task had a different musical stimulus, and each song was only rated once by each participant, the tasks could all be considered as being independent of one another. However, the possible variation between subjects and their individual rating styles could mean that observations were not strictly independent. Therefore, the data was first analysed to determine whether a multilevel model was required for the analysis.

The intra-class correlation value (ICC), which describes how much of the total variation in the dependent variable can be explained by differences between subjects, was calculated by forming an intercepts-only model without predictors and then using residual and intercept variance estimates derived from it. The resultant moderately high ICC value implied that there was a need for a

hierarchical analysis, as interrater variability had an effect on the dependent variable. Linear mixed models were therefor utilised in this analysis, to find which combination of the independent variables (valence, emotional intensity, arousal and familiarity) best predicted the amount of autobiographical memories. Maximum likelihood linear mixed model analyses were run using a random intercept for subjects and a variance components covariance structure to take into account the variance between individual raters. The rating variables valence, emotional intensity, arousal and familiarity were used as fixed effects.

All statistical analyses and data manipulations were executed in IBM SPSS Statistics Version 25. Microsoft Excel was additionally used for the initial categorization of the qualitative data. The analysis of participants' submitted memory inserts was predominantly concerned with statistical analyses involving frequencies, percentage calculations and descriptive statistics.

3 Results

3.1 MEAMs and Associated Factors

As a total of 113 subjects each rated 70 songs, the total number of observations was 113 x 70 = 7910. Tests of normality and visual observation of distributions revealed that the dependent variable Autobiographical Memories was normally distributed (see Appendix A). A Shapiro-Wilk test showed no departure from normality, $W(113) = 0.99$, $p = .49$. As mixed model analyses do not make assumptions about the normality of independent variables, the normality of these will not be discussed further. In the process of calculating intra-class correlation, the test for intercept was statistically significant ($z = 7.11$, $p<.001$), indicating that individuals differed in their means for Autobiographical Memories. The ICC calculation revealed that approximately 19.97% of the variability in Autobiographical Memories was associated with differences between individual raters.

Table 3 displays correlation coefficients between the four independent variables (1-4) and the dependent variable Autobiographical Memories (5). All correlations were relatively high, ranging from r = .34 (Arousal - Familiarity) to r = .79 (Autobiographical memories – Emotional intensity). All correlations were statistically significant at the 0.01 level (2-tailed). Strong correlations between independent variables could cause issues with multicollinearity, but as the rating variables are all theoretically independent constructs, variable reduction or grouping methods were not applied to resolve multicollinearity.

Table 3. *Correlation coefficients between variables.*

	1	2	3	4	5
1. Valence	1				
2. Emotional Intensity	.71	1			
3. Arousal	.70	.65	1		
4. Familiarity	.44	.48	.34	1	
5. Autobiographical memories	.59	.79	.56	.53	1

All correlations coefficients below the main diagonal were significant at the 0.01 level (2-tailed).

Due to the high amount of variation in personal preference and autobiographical relevance between individuals and specific songs, a mixed model analysis was conducted to take into account the variability between raters. Linear mixed model analyses were run using a random intercept model and a variance components covariance structure. The full mixed model analysis including all four independent rating variables returned a model with statistically significant main effects for all four variables. Removing any of the four variables resulted in higher information criteria values compared to the full model, so all four variables were left in the model as explanatory variables.

The final model suggests that the dependent variable Autobiographical Memories can be significantly influenced and predicted by values of Valence, Familiarity, Arousal and Emotional Intensity. All of the rating variables had a positive relationship with the dependent variable, indicating that when ratings of valence, arousal, familiarity or emotional intensity increase, the amount of subject rated autobiographical memories also increases. Emotional Intensity had the strongest positive effect on the dependent variable, followed by Familiarity, Arousal and lastly, Valence (see Table 4).

Table 4. *Estimates of fixed effects for independent variables.*

Variable	Estimate	SE	df	*t*	*p*
Valence	0.04	0.01	7905	2.78	.006
Arousal	0.12	0.01	7900.09	9	.000
Familiarity	0.22	0.01	7821.48	24.4	.000
Emotional Intensity	0.63	0.01	7765.02	53.66	.000

Dependent Variable: Autobiographical Memories.

3.2 Content Analysis of MEAMs

Eighty-one of 113 subjects (71.68%) voluntarily submitted additional written or spoken inserts within the song listening and rating task. The number of song specific inserts submitted per subject ranged from 1 song to all 70 songs. The total amount of inserts submitted by 81 subjects was 2782, computing to a mean of 34.35 inserts per subject. This means that on average, those subjects whom chose to voluntarily submit additional verbal or written detail within the task, submitted inserts for

approximately half of the songs listened to per person (34.35/70). Overall, 35.17% of the total 7910 song presentations in this study prompted subjects to provide additional written or spoken detail. Approximately 20% of all 7910 song presentations in the listening and rating task prompted subjects to give detailed descriptions of their evoked memories.

It is important to note when observing the frequencies of inserts within different categories (Table 5) that one insert could be grouped into multiple categories and sub-categories simultaneously. The mean number of categories and sub-categories assigned to a single insert was 2.8 (range 0:10, SD 1.91, n = 2782). Translated examples of submitted inserts from each category can be found in Appendix D. The inserts were also categorized into two overarching main categories, separating those which were not related to participants' MEAMs and those which were. Less than half (1222 2782, 43.9%) of the inserts were not directly related to describing evoked autobiographical memories but contained other voluntarily submitted content, such as opinions (66.7%), artist-related content (25.7%), associative details (8%), or general information (3.5%). The frequencies and percentages of non-MEAM and MEAM inserts respective to the categories and sub-categories that they were grouped into are displayed in Table 5.

Table 5. *Frequencies and percentages of categories within non-MEAM and MEAM groups.*

	Non-MEAM inserts (total = 1222)	MEAM inserts (total = 1560)	All inserts (total = 2782)
Action Memory	34 (2.8%)	796 (51.0%)	830 (29.8%)
Dancing	1 (0.1%)	222 (14.2%)	223 (8.0%)
Singing	6 (0.5%)	379 (24.3%)	385 (13.8%)
Performing	0 (0.0%)	37 (2.4%)	37 (1.3%)
Listening	27 (2.2%)	224 (14.4%)	251 (9.0%)
Playing(instrument)	0 (0.0%)	24 (1.5%)	24 (0.9%)
Specific detail	14 (1.1%)	546 (35.0%)	560 (20.1%)
Location specific	1 (0.1%)	138 (14.2%)	139 (5.0%)
Object specific	3 (0.2%)	69 (4.4%)	72 (2.6%)
Person specific	11 (0.9%)	336 (21.5%)	347 (12.5%)
Event specific	3 (0.2%)	165 (10.6%)	168 (6.0%)
General events	1 (0.1%)	186 (11.9%)	187 (6.7%)
Lifetime periods	10 (0.8%)	361 (23.1%)	371 (13.3%)
Childhood	0 (0.0%)	97 (6.2%)	97 (3.5%)
Youth	2 (0.2%)	176 (11.3%)	178 (6.4%)
Adulthood	0 (0.0%)	21 (1.3%)	21 (0.8%)
Old age	0 (0.0%)	0 (0.0%)	0 (0.0%)
Semantic content	340 (27.8%)	398 (25.5%)	738 (26.5%)
General Information	43 (3.5%)	23 (1.5%)	66 (2.4%)

Artist related content	314 (25.7%)	386 (24.7%)	700 (25.2%)
Associative detail	98 (8.0%)	412 (26.4%)	510 (18.3%)
Association	55 (4.5%)	96 (6.2%)	151 (5.4%)
Feeling	34 (2.8%)	286 (18.3%)	320 (11.5%)
TV/ Radio	22 (1.8%)	66 (4.2%)	88 (3.2%)
Opinion	815 (66.7%)	434 (27.8%)	1249 (44.9%)
Multiple memories	0 (0.0%)	84 (5.4%)	84 (3.0%)

Conversely, 56.1% of voluntarily submitted inserts and 19.72% of the total 7910 song presentations were recognized as containing a description of a MEAM (Table 5). The most common category within MEAM inserts was Action Memory, with the most common subcategory within Action Memory being Singing, followed by Listening and Dancing. The second most prevalent category of MEAM inserts was Specific Details, the most common subcategory being inserts containing a specific person. Out of the three levels of autobiographical knowledge (Conway & Pleydell-Pearce, 2000), lifetime periods represented the most common category, followed by general events and event specific knowledge. The most common age-related sub-category within lifetime periods was Youth, followed by Childhood and Adulthood.

Songs were also grouped by the decade in which they were popularized in Finland (50s, 60s, 70s and 80s), with folk songs placed into a separate group as these did not have a distinct recorded time of popularization. The frequencies and percentages of MEAM insert categories are displayed within decades of popularization in Table 6. The cross-table comparison of MEAM insert groups by decades of popularization revealed that overall, the largest portion of MEAM inserts were submitted for songs that had been popularized in the 50s. The second largest portion of inserts in total were submitted for folk songs, followed by 60s, 70s and finally 80s songs. A similar trend was replicated within individual categories also, with the largest portion of inserts generally being submitted for 50s songs and overall frequencies decreasing towards more recent decades.

Table 6. *Frequencies of MEAM inserts by categories (rows) within decades of popularization (columns), followed by percentage from group total in parentheses.*

	50s songs (1950-59)	60s songs (1960-69)	70s songs (1970-79)	80s songs (1980-89)	Folk songs	Group Total
Action Memory	204 (25.7%)	146 (18.4%)	114 (14.3%)	97 (12.2%)	234 (29.4%)	795
Specific detail	176 (32.7%)	121 (22.5%)	80 (14.9%)	66 (12.3%)	95 (17.7%)	538
Lifetime periods	115 (32.1%)	99 (27.7%)	60 (16.8%)	25 (7.0%)	59 (16.5%)	358

Semantic content	128 (32.2%)	116 (29.1%)	72 (18.1%)	70 (17.6%)	12 (3.0%)	398
Associative detail	118 (29.1%)	86 (21.2%)	62 (15.3%)	66 (16.3%)	73 (18.0%)	405
MEAM inserts in total	434 (28.0%)	342 (22.1%)	240 (15.5%)	190 (12.3%)	343 (22.1%)	1549

4 Discussion

This study sought to investigate factors related to the elicitation of music-evoked autobiographical memories (MEAMs) in healthy aging to improve overall understanding of the phenomenon and to enhance the selection of optimal musical stimuli to be used for the neurological rehabilitation and care of elderly individuals. The characteristic contents of MEAMs of healthy older individuals were also explored.

4.1 MEAMs and Associated Factors

The first part of the study, *MEAMs and Associated Factors,* aimed to explore how valence (how much a song is liked or disliked), emotional intensity (the strength of emotion attached to a song), arousal (how a song impacts current states of arousal) and familiarity (how familiar a song feels to an individual), were associated to autobiographical salience (how many autobiographical memories were evoked by the song). Correlational analyses revealed that all five variables had statistically significant positive relationships with one another. Furthermore, mixed model analyses revealed that valence, emotional intensity, arousal and familiarity all had significant positive effects on the dependent variable autobiographical salience, and the best fitting model included all four rating variables. Therefore, in order to maximally evoke MEAMs in healthy elderly individuals, selected musical stimuli should be regarded by the listener as being pleasant, emotionally intense, physiologically arousing and familiar.

These results indicate first of all that as subjectively rated values of valence increase (low value indicates negative valence and high value indicates positive valence), self-assessed amounts of MEAMs increase. An interpretation of this would yield, that music which is regarded as being more pleasant generally evokes more autobiographical memories than music which is regarded as less pleasant. The finding supports Krumhansl and Zupnick's (2013) research, which showed that participants had a higher number of personal memories when listening to music with high valence ratings. This partially unexpected positive relationship could also be mediated by the *positivity effect* (Kennedy, Mather & Carstensen, 2004), which denotes that elderly participants tend to remember

past events more positively with time. Perhaps the increased recall of positive memories in seniors influences how pleasant an associated piece of music is considered, leading to higher ratings of valence.

The results also support what was hypothesized of the relationship between subjectively rated emotional intensity and evoked MEAMs. When emotional intensity is rated as being low, there is a smaller incidence of reported MEAMs. Conversely, when emotional intensity is rated as being higher, the amount of reported MEAMs is also higher. This relationship could be interpreted either so that songs which make people feel intense emotions are more likely to elicit MEAMs, or contrarily so that songs which elicit MEAMs are more likely to cause strong emotional reactions in individuals.

Furthermore, the results indicate that higher levels of subjectively rated arousal predict higher amounts of autobiographical memories. Subsequently, a decreased state of arousal predicts lower amounts of autobiographical memories. This result fits the hypothesized outcome as well as Krumhansl and Zupnick's (2013) findings discussed earlier, namely that songs which evoke autobiographical memories generally tend to increase states of arousal. However, the relationship between physiological arousal and MEAMs is undoubtedly more complex and ultimately affected by numerous situational and individual level factors (Dillman, 2007). To understand this relationship beyond results of overall self-rated effects, it should be further explored by methods such as physiological measurement or brain imaging.

Lastly, the results coincide with the hypothesis asserting that a positive relationship exists between subjectively rated song familiarity and MEAMs, so that songs which are rated as being more familiar elicit more MEAMs than songs which are rated as less familiar. This finding supports previous literature, which has repeatedly confirmed the existence of a strong connection between the familiarity and autobiographical salience of music (Belfi et al., 2016; Ford et al., 2016; Janata et al., 2007).

4.2 Content Analysis of MEAMs

The second part of this study, *Content Analysis of MEAMs*, undertook an explorative methodological approach to advance understanding of the characteristic contents of MEAMs in healthy aging populations by analyzing participants' verbal reports of MEAMs. These verbal memory descriptions were submitted by participants voluntarily within the assigned music listening and rating task. Ultimately, the content analysis aimed to find out what kinds of information and levels of detail

MEAMs of healthy elderly individuals generally contain. Results showed that they often involved music-related activity, such as singing, dancing or listening to music. They also frequently contained details of specific people or locations. Memories from adolescence were more common than other life periods and they weren't generally very temporally specific.

The careful case-by-case analysis revealed that just over half of the submitted memory descriptions involved active participation in a music related activity. The most common of these was activities was singing, which was followed by listening to music, dancing and lastly playing an instrument. Comparing these results of healthy elderly individuals to the previously discussed study by Janata et al. (2007), where dancing, singing and driving were found to be the most common activities in MEAMs of college aged participants, singing and dancing appear to be equally prominent in the MEAM contents of older individuals.

The fact that actively listening to music was a prominent theme in this study of seniors and not in previous research involving college-aged participants (Janata et al., 2007) may reflect generational differences in how music is consumed. In earlier decades the act of listening to music was probably considered more often an activity in itself, whereas in recent years the increased availability of music in people's everyday lives has moved music listening more into the background. Another generational and cultural difference uncovered between these two memory content analyses was that Janata et al. (2007) found driving to be one of the key activities mentioned in MEAMs. This greater frequency of driving related memories may be explained by the fact that their pool of participants consisted of undergraduate students from UC Davis in California and express the prominence of driving cars in American youth culture.

Reflecting on the vast amount of musical activity found in elderly individuals' submitted memory contents, it is important to note that the majority of participants recruited for this study were senior choir singers. Senior individuals who actively participate in choir singing undoubtedly have increased overall musical involvement in their daily lives, which might partially skew results to over-represent memory contents involving singing, performing and playing instruments. This partial misrepresentation of action related memory content should be taken into account when considering the applicability of these results to more general senior populations.

More than a third of MEAM descriptions in this study contained some kind of specific detail, such as specific people, locations, events or objects. These results seem to resemble the findings of Janata el

al. (2007), who also found that memories involving a specific person or people were the most common, followed by memories containing a specific location or event. Comparing to this study, the absolute proportions of these different types of specific memories were larger across all categories in Janata et al.'s (2007) study. These greater percentages may reflect the fact that they used a more rigorous set of follow up questions in their music listening and rating task, asking participants to label their MEAMs with a ready list of association categories (Event, Period, Person/People, Place, None of the above). This study used a more liberal and ecologically valid method for determining memory contents, as participants were given the chance to freely describe their evoked memories without additional specified questions.

Memories were also grouped into three categories representing the different levels of autobiographical knowledge (Conway & Pleydell-Pearce, 2000) and temporal specificity. Memories containing mentions of lifetime periods appeared to outweigh memories that were more temporally specific, such as memories of specific events or general events. These results also roughly resemble those of Janata et al. (2007), who found that memories of lifetime periods represented approximately double the amount of memories containing specific events. Both studies indicate that MEAMs aren't typically locked into a specific moment in time and generally involve a broader timespan, encompassing entire life periods. These results support concluding that music is an especially effective cue for evoking autobiographical memories that are not temporally specific and are more general, spanning widespread periods of a person's life.

In alignment with previous research on the reminiscence bump (Schulkind et al., 1999) and the asserted hypothesis, the results showed that the most commonly mentioned age-related lifetime period was the period of youth, representing memories from 15-24 years of age. Memories from this period were significantly more frequent than memories from other periods of life, with childhood memories being the second most common. There were only a handful of memories linked to adulthood and none reported from old age. The most common explanation given for the existence of this reminiscence bump is that the period of youth is when people usually experience things for the first time in life. These novel experiences are thought to be better preserved in memory and thus consequently arise more readily during autobiographical recall (Rathbone, Moulin & Conway, 2008).

Considering that memories from youth and childhood are more frequent than memories from adulthood or old age, a similar age-related pattern would be expected to emerge from the perspective of the memory evoking musical stimulus. From observing frequencies of evoked memories relative

to the decade in which each corresponding song was made popular (50s, 60s, 70s, 80s, folk songs), a clear trend emerged revealing that songs from earlier decades generally evoked more memories than songs from later decades. Specifically, the largest portion of memories were evoked by songs from the 50s, with frequencies generally decreasing towards earlier decades. Folk songs appeared to evoke approximately as many memories as 50s and 60s songs, which may reflect the fact that these traditional Finnish songs are commonly heard in childhood and youth years spent at school. Bearing in mind that participants were 60 to 86 years of age, songs popularized during the 50s and 60s would have emerged around the same time of most participants' childhood years and adolescence. This suggests that to evoke maximal amounts of MEAMs, music should be selected from an individual's younger years as opposed to more recently released music.

Results from the content analyses further revealed that just under a fifth of submitted MEAMs involved a distinct mention of remembering a particular feeling or emotion, which was associated with the autobiographical memory. This finding fits the collectively understood close connection shared between emotions and memories and supports the notion that emotions have a key role in the retrieval and encoding of personally salient events (Holland & Kensinger, 2010). Considering the strong positive relationship found between emotional intensity and elicited MEAMs in the first part of this thesis, it is understandable that a sizable portion of described memories would include descriptions of associated emotions. Additionally, almost a quarter of submitted MEAMs included a mention or information about the song excerpts' performer/artist. This indicates that artist related semantic information is often simultaneously recalled with MEAMs and further suggests that knowledge of whom is singing or performing the particular musical piece could be an important factor in the process of evoking autobiographical memories by music.

4.3 Strengths and Limitations

A few methodological issues regarding this study are important to be discussed further. Firstly, as the listening and rating task entailed each subject listening to and rating 70 individual songs, it is clear that the group of submissions made by an individual participant would resemble each other due to person-specific rating styles. Statistical analyses revealed variation in rating style between individual subjects, which may have resulted in individual observations not being regarded as independent of one another. However, this issue was contested by implementing specific statistical models that took into account the interrater variability.

Secondly, the analyses of submitted MEAM contents revealed that some participants may have misunderstood the instruction to voluntarily submit memory detail within the task. The task instruction held that after hearing and rating each song, participants *could* describe their evoked autobiographical memories if they personally wanted to share them. This instruction seemed to be occasionally misunderstood to indicate that verbal submissions were compulsory and not voluntary as intended. Furthermore, a large portion of the submitted verbal material did not include descriptions of evoked autobiographical memories as instructed, but contained other voluntarily submitted content, such as opinions, associative details or other semantic information. This issue was taken into account in the content analysis process by grouping submitted material into separate Non-MEAM and MEAM groups. Moreover, it is important to note that as this task was indeed voluntary by nature, some participants will have chosen not to share their MEAMs and thus these memories will remain a mystery and unaccounted for in this study.

Thirdly, the listening and rating task developed for this project was completed by subjects entirely by way of self-report. In order to get more reliable results and avoid the impact of self-report biases, this study should be replicated by alternative means of evaluation. For example, physiological measurement methods could be implemented to measure listeners' physiological responses to pieces of music and to capture implicit responses and reactions which are otherwise hard to put into words. Although brain imaging techniques have been used in previous studies of MEAMs in college age students (Janata et al., 2009), these should also be implemented in order to investigate how the experience of MEAMs manifests in the brains of healthy elderly individuals specifically.

Another important methodological factor to be discussed is that the entire process of analyzing MEAM contents was completed manually. This lengthy process included two researchers consistently reading through and categorizing each of the 2782 inserts into assorted categories, case-by-case. Using this manual method for interpreting and categorizing memory inserts could either be seen as a strength or limitation. It may be more prone to error and subjective bias effects than alternative automated or technical methods, such as the word count analysis used in the study by Janata et al. (2007). However, the implemented manual method probably allowed for more contextual details to be captured and possibly resulted in a more comprehensive understanding of the submitted memory descriptions, compared to a single word count analyses, for example. Perhaps future studies of MEAM contents would benefit from making use of advanced algorithms in modern word analysis software which could capture intricate details from memory descriptions faster and more reliably than by manual means.

Finally, due to the idiosyncratic nature of musical preferences, ideal circumstances would allow individuals to freely self-select music that they hold personally important to ensure high familiarity with songs and to generate maximal amounts of MEAMs. Unfortunately, self-selected music may not always be readily available, and in some circumstances elderly individuals might not be capable of reciting or remembering specific personally relevant songs (for example, in more advanced stages of dementia or communication impairment, such as aphasia). Using an experimenter-selected pool of popular music as stimuli instead of patient-selected songs proved to be an effective method for drawing out autobiographical memories in elderly individuals in this study. Opting for a ready list of collectively familiar songs also has the added benefit of not requiring patients with memory loss or other disabilities, which limit their ability to verbalize musical preferences, to have to provide information on their preferred musical pieces.

4.4 Conclusions

The purpose of investigating the relationship between the measured memory, emotion and attention related variables; valence, emotional intensity, arousal, familiarity and autobiographical salience in healthy elderly individuals was to increase understanding of factors linked to the elicitation of MEAMs and to ultimately improve future selection of optimal musical stimuli to be used for neurological rehabilitation and care with older adults. Concluding from the results of the first part of this thesis, *MEAMs and Associated Factors,* it seems that in order to maximize the probability of evoking MEAMs in elderly individuals, the selected musical stimuli should be music that the listener regards as being pleasant, emotionally intense, physiologically arousing, and familiar.

Concluding from the comprehensive analysis of MEAM contents, elderly individuals' MEAMs appear to often involve some kind of music related activity, such as singing, dancing or listening to music. Additionally, their MEAMs regularly also contain some kind of specific memory detail, most commonly of specific people or distinct locations. MEAMs of elderly individuals are generally not very temporally specific and more frequently include recollections of general lifetime periods than of specific events from life. They often also include semantic details, usually information that is related to the artist or performer of the song. Finally, elderly individuals seem to evoke the most memories from adolescence, followed by childhood and to a lesser extent adulthood. Therefore, to maximally evoke autobiographical memories in circumstances where patient-selected music is not an option, musical stimuli should be preferably chosen from periods of youth and childhood rather than later periods of life.

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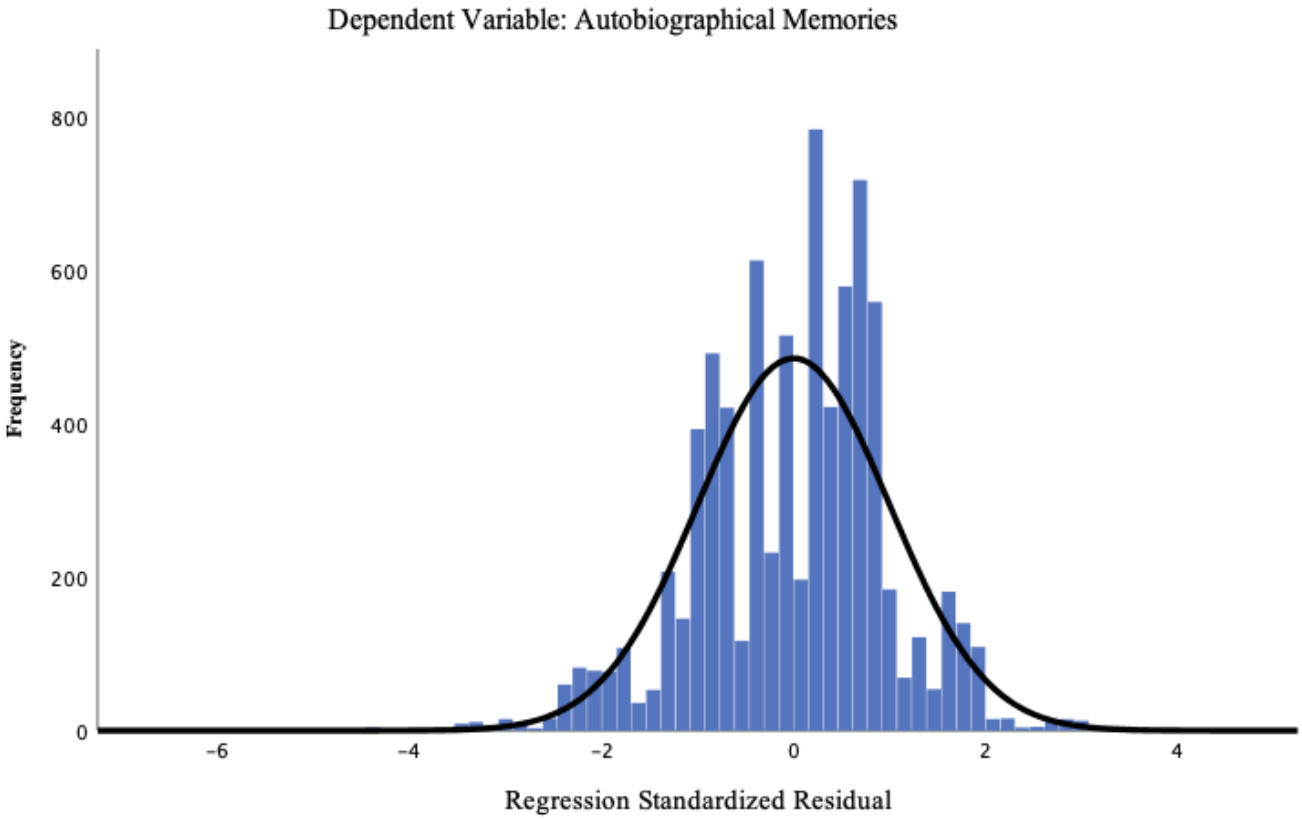
***Appendix A*.** Histogram of sample distribution with normal distribution curve



Appendix B. List of songs used in the study

Table A1. *List of songs used in the study by decade and year popularized in Finland.*

	Performer and song title	Year popularized
50s (1950-1959)	Pirkko Jaakkola - Pariisin taivaan alla	1953
	Laila Kinnunen - Lazzarella	1958
	Eila Pienimäki - Vanhan veräjän luona	1959
	Kipparikvartetti - Kaunis Veera	1950
	Olavi Virta - Sokeripala	1954
	Juha Eirto - Tiikerihai	1955
	Eero Väre - Kultainen nuoruus	1949
	Lasse Liemola - Anna pois	1959
	Doris Day - Whatever Will Be, Will Be [Que Sera, Sera]	1956
	The Platters - Smoke Gets in Your Eyes	1958
	Little Richard - Long Tall Sally	1956
	Harry Belafonte – Day-O (The Banana Boat Song)	1956
	Nat King Cole - Quizás, quizás, quizás	1959
	Louis Armstrong - Mack the Knife	1956
	Chris Barber - Petite Fleur	1959
	Metro-tytöt - Orvokkeja äidille	1955
	Helena Siltala - Ranskalaiset korot	1958
	Annikki Tähti - Kuningaskobra	1956
	Brita Koivunen - Suklaasydän	1956
	Tapio Rautavaara - Isoisän olkihattu	1951
	Kauko Käyhkö - Rovaniemen markkinoilla	1951
	Georg Ots - Saarenmaan valssi	1957
	Veikko Tuomi - Vanhan vaahteran laulu	1952
	Rosemary Clooney - Mambo italiano	1954
	Pat Boone - Love Letters in the Sand	1958
	Bill Haley - Rock Around the Clock	1954
	Elvis Presley - Heartbreak hotel	1956
	The Four Lads - Istanbul [Not Constantinople]	1953
	Louis Prima - Buona Sera	1956
	Glenn Miller - Moonlight Serenade	1954
60s (1960-1969)	Tamara Lund - Sinun omasi	1965
	Katri Helena - Minne tuuli kuljettaa	1965
	Reijo Taipale - Tähdet meren yllä	1964
	Mauno Kuusisto - Kertokaa se hänelle	1960
	Danny - Piilopaikka	1965
	Kari Kuuva - Tango pelargonia	1964
	Four Cats - Suuret setelit	1963
	Dusty Springfield - You Don't Have to Say You Love Me	1966
	Billy J. Kramer & The Dakotas - Bad to Me	1963
	The Monkees - I'm a Believer	1966
	The Rolling Stones - The Last Time	1965

	The Animals - House of the Rising Sun	1964
	The Swinging Blue Jeans - Hippy Hippy Shake	1964
	Stan Getz & João Gilberto - The Girl from Ipanema	1964
	Ray Charles - Hit the Road Jack	1961
	Vieno Kekkonen - Ei koskaan sunnuntaisin	1960
	Pirkko Mannola - Kuinka rakkaus alkoi	1960
	Pasi Kaunisto & Nacke Johansson's Orchestra - Koskaan et muuttua saa	1969
	Eino Grön - Sä kuulut päivään jokaiseen	1966
	Aikamiehet - Iltatuulen viesti	1967
	Johnny - Hyvin menee kuitenkin	1966
	Eero Raittinen - Vanha holvikirkko	1968
	The Sounds - Emma	1963
	The Beatles - All My Loving	1964
	Tom Jones - Delilah	1968
	Simon & Garfunkel - Bridge Over Troubled Water	1969
	Procol Harum - A Whiter Shade of Pale	1967
	The Beach Boys - Good Vibrations	1966
	The Renegades - Cadillac	1964
	Aretha Franklin - Chain of Fools	1967
70s (1970-1979)	Vicky Rosti - Tuolta saapuu Charlie Brown	1976
	Merja Rantamäki - Mistä mä löytäisin sen laulun	1976
	Jukka Kuoppamäki - Kultaa tai kunniaa	1973
	Jussi & the Boys - Metsämökin tonttu	1974
	Hector - Olen hautausmaa	1973
	Jamppa Tuominen - Aamu toi, ilta vei	1977
	Irwin Goodman - St. Pauli ja Reperbahn	1970
	ABBA - Waterloo	1974
	Lynn Anderson - Rose Garden	1971
	Elton John - Crocodile Rock	1973
	The Rubettes - Sugar Baby Love	1974
	Creedence Clearwater Revival - Travelin' Band	1970
	Donna Summer - Hot Stuff	1979
	Carl Douglas - Kung Fu Fighting	1974
	Katri Helena - Syysunelma	1976
	Fredi - Puhu hiljaa rakkaudesta	1972
	Erkki Junkkarinen - Ruusuja hopeamaljassa	1975
	Kai Hyttinen - Dirlanda	1972
	Leevi & the Leavings - Mitä kuuluu, Marja-Leena?	1978
	Tuomari Nurmio - Valo yössä	1972
	Hurriganes - Get on	1974
	Kontra - Jerry Cotton	1977
	Baccara - Yes Sir, I Can Boogie	1977
	Middle of the road - Chirpy Chirpy Cheep Cheep	1972
	Uriah Heep - Lady in Black	1971
	Christie - Yellow River	1970

	Led Zeppelin - Whole Lotta Love	1970
	Roberta Flack - Killing Me Softly with His Song	1973
	Boney M. - Rivers of Babylon	1978
	Deep Purple - Black Night	1972
80s (1980-1989)	Paula Koivuniemi - Tummat silmät, ruskea tukka	1980
	Vera Telenius - Miljoona ruusua	1984
	Topi Sorsakoski - Eeva	1985
	Kirka - Surun pyyhit silmistäni pois	1988
	Pirkka-Pekka Petelius - Muistan sua Elaine	1984
	Miljoonasade - Marraskuu	1988
	Leevi & the Leavings - Pohjois-Karjala	1986
	Pelle Miljoona - Moottoritie on kuuma	1980
	Barbara Streisand - Woman in Love	1980
	Madonna - Papa Don't Preach	1987
	Toto - Africa	1983
	David Bowie - Let's Dance	1983
	Earth, Wind & Fire - Celebration	1980
	Marvin Gaye - I Heard It Through the Grapevine	1982
	Diana Ross - Upside Down	1980
	Jari Huhtasalo - Äideistä parhain	1990
	Tuula Amberla - Lulu	1984
	Lea Laurila - Ei oo, ei tuu	1980
	Matti & Teppo - Mä näitä polkuja tallaan	1982
	Rauli Badding Somerjoki - Tähdet tähdet	1983
	Juice Leskinen - Kaksoiselämää	1986
	J. Karjalainen ja Mustat Lasit - Doris	1985
	Juha Vainio ja Hyvän Tuulen Laulajat - Albatrossi	1980
	Eppu Normaali - Kitara, taivas ja tähdet	1985
	Blondie - Call Me	1980
	Michael Jackson - Billie Jean	1982
	Tina Turner - Typical Male	1984
	Leonard Cohen - Dance Me to the End of Love	1985
	Ottawan - Hands Up	1980
	Stevie Wonder - I Just Called to Say I Love You	1984
Folk	Tuoll' on mun kultani	
	Kalliolle kukkulalle	
	Tuonne taakse metsämaan	
	Kotimaani ompi Suomi	
	Yksi ruusu on kasvanut laaksossa	
	Leivo	
	Säkkijärven polkka	
	Tulatullallaa	
	On neidolla punapaula	
	Laulu Suomessa	
	Taivas on sininen ja valkoinen	
	Soittajapaimen	

	Kotini
	Lapsuuden toverille
	Sunnuntaiaamuna
	Jos sais kerran reissullansa
	Minun kultani kaunis on
	Täällä yksinäni laulelen
	On suuri sun rantas autius
	Heili Karjalasta

Appendix C. Original examples of inserts by category (in Finnish)

GROUP	SUB-GROUP	ORIGINAL INSERT IN FINNISH
Action memory	Dancing	*"Tämän kappaleen tahdissa olen monta kertaa tanssinut yökerhossa – saa nivelet ja luut liikkeelle"* (Little Richard - Long tall sally)
	Singing	*"Muistan laulaneeni tätä joskus nuorena porukalla - siihen liittyy muisto koulun juhlista"* (Harry Belafonte - Day O (Banana boat song))
	Performing	*"Varhaisteineinä teimme tästä kappaleesta serkkujen kanssa tanssiesityksen naapureille. Harjoittelu oli tosi hauskaa ja saamamme aploodit myös."* (The Four Lads – Istanbul (Not Constantinople)
	Listening	*"Lapsuudessa kuuntelin tätä paljon, meillä oli levy kotona!"* (Laila Kinnunen – Lazzarella)
	Playing (instrument)	"*Kuusikymmenluku; hoidin veljeni lapsia kesällä ja viihdytin heitä soittamalla laulukirjasta kappaleita. Lauloimme niitä yhdessä, tämä yksi sellainen.* " (Folk song - Yksi ruusu on kasvanut laaksossa)
Specific memory	Location specific	*"Tämän laulajan tapasin heidän vieraillessaan Hotelli Marina Palacessa, vuotta en muista 1978-1980 mailla ehkä. Mexicon lahdella kuuntelimme tätä kappaletta usein."* (The Platters - Smoke gets in your eyes)
	Object specific	"*Tästä tulee taas lapsuus mieleen ja sisaret ja isän gramofoni"* (Juha Eirto – Tiikerihai)
	Person specific	*"Rakas tätini Tuija opetti kymmenvuotiasta minua tanssimaan foxtrottia kanssaan kotimme eteisessä..."* (Helena Siltala - Ranskalaiset korot)
	Event specific	*"Kun täytin 50 v, isoksi kasvanut tarhalapseni tuli ja soitti pianolla ja lauloi tämän kappaleen minulle*" (Olavi Virta – Sokeripala

	General events	*”10-13 vuoden iässä ollessani perheemme teki autoretkiä Suomessa. Autossa ei ollut radiota ja niinpä lauloimme mm. tätä laulua monet kerrat.”* (Folk song – Laulu Suomessa)
Lifetime period	Childhood	*”Kuuluu lapsuuden aikaisiin musiikkimuistoihin radiossa sunnuntaisin.* ” (Rosemary Clooney – Mambo Italiano)
	Youth	*”Tästä tuli heti mieleen teiniaika ja oma akustinen kitara, jolla pystyin jopa muutaman soinnun näppäilemään säestääkseni itseäni, kun lauloin tätä.”* (The Animals - House of the rising sun)
	Adulthood	*”Kuunneltiin avioliiton alkuaikoina. Sohvalla istumista ja nuori vaimo kainalossa. ”* (Simon & Garfunkel - Bridge over troubled water)
Semantic Content	General information	”*Muistan kun tämä kappale tuli markkinoille, Soi paljon radiossa. Kriitikot lyttäsivät mutta kansa tykkäsi*.” (Kari Kuuva - Tango pelargonia)
	Artist Related information	*”Erikoista: vahvasti näistä Abban kappaleista monista tulee iholle "kylmät väreet", niiden on pakko vaikuttaa johonkin hermostossa! Euroviisuvoitto 1974, siitä tuli riemuvoitto silloin ja hyvä mieli.”* *(*Abba – Waterloo)
Associative detail	Association	*”Äiti on kotoisin Pohjois-Karjalasta. Tuo mieleen hänen kotinsa ja serkut Pohjois-Karjalassa.”* *(*Folk song - Heili Karjalasta)
	Feeling	*”Tätä laulua kuunnellessani olen nuoresta asti tunnelmoinut ja ihastellut, miten nuori rakkaus joskus kantaa rauhalliseen rakastavaan vanhuuteen.”* (Tapio Rautavaara - Isoisän olkihattu)
	TV/Radio	*”Edelleen ihanaa 60-lukua, silloin käytiin katsomassa Beatlesin eka leffakin ’a hard days night’”* (The Beatles - All my loving)

	Opinion	*”Laulu on lämmin ja tuo muistoja elämän hyvistä hetkistä.”* (Barbara Streisand - Woman in love)
	Multiple memories	*“Herättää muistoja tilaisuuksista, missä olen kuullut tämän, konserteissa, juhlissa tai muissa”* (Leonard Cohen - Dance me to the end of love)

Appendix D. Translated examples of inserts by category (in English)

GROUP	SUB-GROUP	EXAMPLE INSERT (translated from Finnish)
Action memory	Dancing	*"I've danced to the rhythm of this song several times at night clubs – gets my bones and joints moving"* (Little Richard - Long Tall Sally)
	Singing	*"I remember singing this in a group when I was young – this is linked to a memory of a school celebration"* (Harry Belafonte - Day O (Banana boat song))
	Performing	"*Me and my cousins made a dance performance of this song for my neighbors in our early teens. Practicing was a lot of fun as was the round of applause we received."* (The Four Lads – Istanbul (Not Constantinople))
	Listening	*"I listened to this song a lot in my childhood, we had the record at home."* (Laila Kinnunen – Lazzarella)
	Playing (instrument)	*"It's the 60s. I was looking after my brother's children in the summer, and I kept them entertained by playing some songs to them from a songbook. We would sing along together - this was one of those songs."* (Folk song - Yksi ruusu on kasvanut laaksossa)
Specific Memory	Location specific	*"I met this singer when the group was staying at Hotel Marina Palace. I can't remember the year, 1978-1980 perhaps. We listened to this song a lot on the Gulf of Mexico."* (The Platters - Smoke gets in your eyes)
	Object specific	"*This reminds me of my childhood, my siblings and dad's gramophone."* (Juha Eirto – Tiikerihai)
	Person specific	"*My beloved aunt Tuija was teaching ten-year-old me to dance foxtrot in the hallway of our home"* (Helena Siltala - Ranskalaiset korot)
	Event specific	*"When I turned 50, my fully-grown playschool kid came and sang this song to me whilst playing the piano."* (Olavi Virta – Sokeripala)

	General events	*"When I was 10-13 years old, my family made many car trips around Finland. The car didn't have radio, so we often used to sing songs instead (including this one)"* (Folk song – Laulu Suomessa)
Lifetime period	Childhood	*"This one belongs to the music memories of my childhood and Sundays listening to the radio."* (Rosemary Clooney – Mambo Italiano)
	Youth	"*This brings to mind my teenage years and my acoustic guitar with which I could play a few chords whilst singing this song*" (The Animals - House of the rising sun)
	Adulthood	" *We listened to this in the early years of our marriage. Sitting on the couch with a young wife in my arms*". (Simon & Garfunkel - Bridge over troubled water)
Semantic Content	General information	*"I remember when this track hit the markets. It was playing a lot on the radio. Critics disapproved but the people liked it."* (Kari Kuuva - Tango pelargonia)
	Artist related content	*"How peculiar... These ABBA songs give me a strong feeling of "the chills" on my skin. They must be affecting something in my nervous system! Their Eurovision victory in 1974 was a real triumph and made me happy."* *(*ABBA – Waterloo)
Associative detail	Association	*"My mother is from North Karelia. This brings to mind her home and my North Karelian cousins."* (Folk Songs – Heili Karjalasta)
	Feeling	*"Since listening to this song in my youth, I have sentimentally appreciated how young love can sometimes carry on and turn into peaceful love in old age."* (Tapio Rautavaara - Isoisän olkihattu)
	TV/ Radio	*"Again, the lovely 60s. We went to see the Beatles' first movie, 'a hard day's night'." (*The Beatles – All my loving)
Other Content	Opinion	*"This song is warm and brings back memories of the better moments in life."* (Barbara Streisand - Woman in love)

Multiple memories	*"Awakens memories of different events where I've heard the song - concerts, parties and others."* (Leonard Cohen - Dance me to the end of love)